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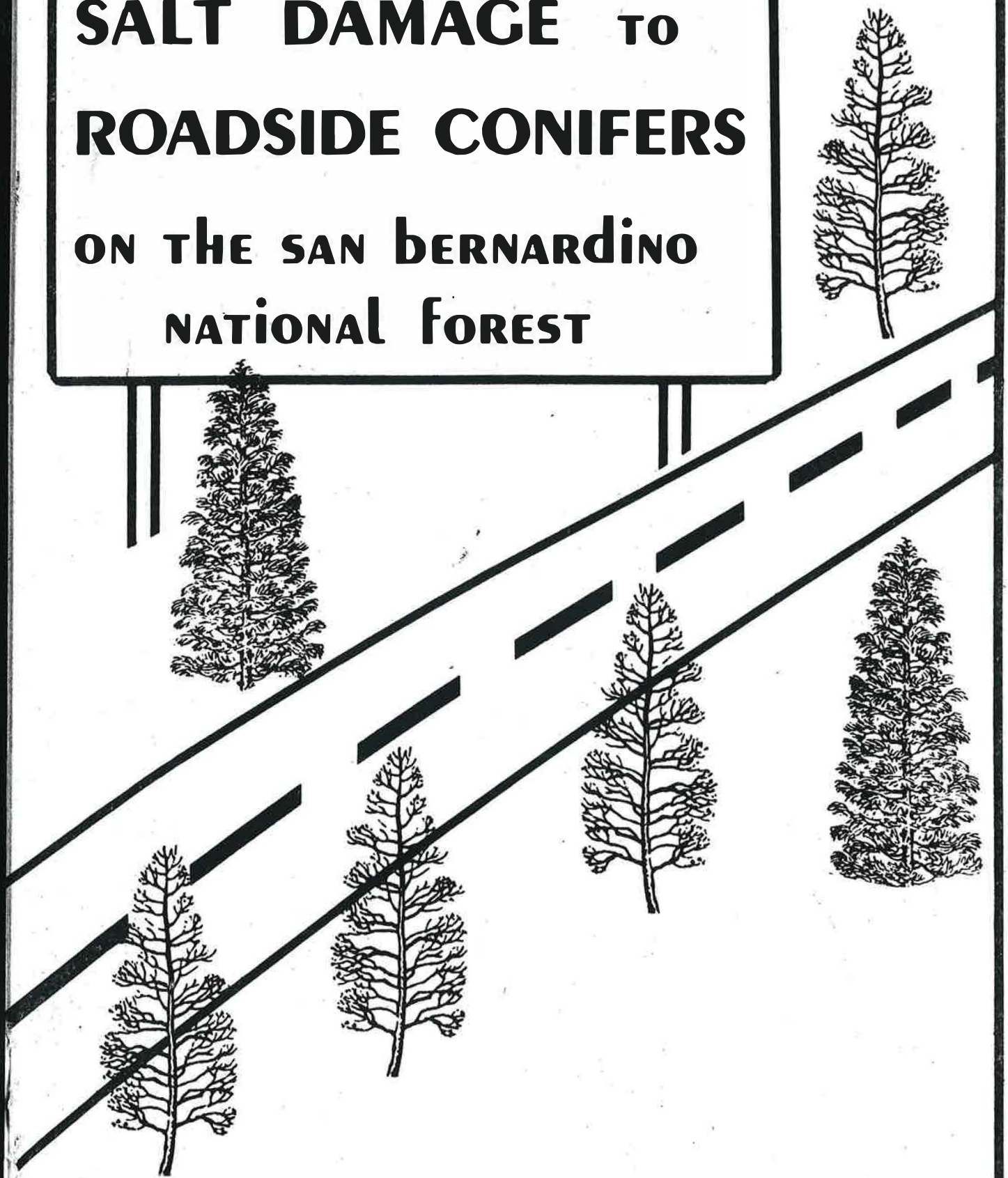
SALT DAMAGE TO ROADSIDE CONIFERS ON THE SAN BERNARDINO NATIONAL FOREST



FOREST INSECT & DISEASE MANAGEMENT
USDA FOREST SERVICE CALIFORNIA REGION

SALT DAMAGE TO ROADSIDE CONIFERS ON THE SAN BERNARDINO NATIONAL FOREST

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May 1976

FOREST INSECT AND DISEASE MANAGEMENT
USDA, Forest Service, California Region

LABORATORY

INTRODUCTION

In 1973 damage to conifers was observed along the shoulders of highway 38 between Camp Angelus and Barton Flats; however damage did not appear to increase significantly in 1974. The following winter 107 inches of snow fell in the Camp Angelus area, and the CalTrans Camp Angelus Maintenance Station applied 138 tons of salt to 26.9 miles of highway 38 from Forest Falls junction to Onyx Summit. The following spring there was a significant increase of damage to roadside conifers in this area. Because of this damage the Forest Supervisor of the San Bernardino National Forest requested a biological evaluation to determine the cause and distribution of the damage to roadside conifers.

SCOPE AND OBJECTIVES

From a preliminary examination of the areas in which the damage was occurring Forest personnel observed that all the damaged trees were close to the highway. They collected foliage specimens and sent them to Forest Insect and Disease Management for analysis. The symptoms on these foliage specimens were typical of those associated with salt damage.

Therefore, this evaluation was limited to determining if highway deicing salt was causing damage to and killing roadside conifers along the major State and County roads within the boundaries of the San Bernardino National Forest.

To accomplish this task there were three objectives:

- To determine the distribution of dead and damaged roadside conifers within the San Bernardino National Forest.
- To determine if there was a relationship between the concentration of chloride ions in the conifer foliage and damage rating.
- To determine if there was a relationship between conifer damage and proximity to the highways that had been salted.

METHODS

DETECTION AND INCIDENCE SURVEY

In June 1975 a survey was made along the major state and county highways in the San Bernardino National Forest to determine the extent and severity of salt damage to conifers. All trees or groups of trees growing within 200 feet of highways and appearing to have been damaged by salt were recorded and plotted on a map.

The symptoms of salt damage to certain conifers have been described by other observers (Monk and Peterson, 1962; Spotts, et al, 1972; Strong, 1944; Scharpf and Srago, 1974). These descriptions fit the symptoms observed on the species in the San Bernardino National Forest.

To confirm that the diagnostic symptoms used to identify salt-damaged trees were accurate, foliage samples exhibiting the symptoms described below were collected from the crowns of 60 individual coniferous trees of different species and sent to the laboratory for analysis. The following data were recorded for each tree: species, d.b.h., damage rating, distance from the highway, and location. All trees sampled were within 50 feet of deiced highways. As a control, in nearby sites not exposed to deicing salts foliage samples were collected from trees of each study species: Jeffrey pine (Pinus jeffreyi Grev. & Balf.), sugar pine (Pinus lambertiana Dougl., white fir (Abies concolor (Gord. & Flend.) Lindl.), incense-cedar (Libocedrus decurrens Torr.), and ponderosa pine (Pinus ponderosa Laws.).

The salt damage ratings used in all studies were based on the following criteria: (2)

No Damage	- No tipburn or needle browning. Chlorotic trees were included in this rating until further symptoms developed.
Light Damage	- One-third or less of the foliage damaged, with only the very tips of the needles showing tipburn.
Moderate Damage	- One-third to two-thirds of the foliage damaged, and one-half or less of the length of the damaged needles on pines showing tipburn.
Severe Damage	- Two-thirds or more of the foliage damaged, and on pines 50 percent or more of the needle length showing tipburn. Trees completely brown and apparently dead were included in this category.

LABORATORY ANALYSIS

Analyses were made on the samples of damaged and healthy foliage described above. Samples from each tree were placed in a paper bag and dried in a forced air oven at 60 C for 12 hours. The dried tissue was then ground to pass through a 40-mesh screen, placed in a screw cap vial, and submitted for chloride analysis to the Statewide Air Pollution Research Center, Univ. of Calif, Riverside, Calif.

SYMPTOMS (2)

The following are descriptions of the symptoms of salt damage on the major conifers in the Tahoe Basin. These same symptoms apply to conifers in the San Bernardino National Forest.

The Pines. Symptoms were essentially the same for all pine species observed (Jeffrey pine, ponderosa pine, and sugar pine). Tip dieback (or tip burning) of the youngest foliage is the most conspicuous and distinctive symptom of salt damage. The precise time of year when this dieback begins on new foliage is not known; however, the current year's foliage may show conspicuous dieback before the buds break in the spring. Dieback progresses with time, and is uniform along all the needles on a single branch. The margin between dead and living tissue is very distinct, resulting in branches and trees that exhibit a "halo" of dead foliage tips when the damaged branches are observed frontally. Needle banding, as described by Spotts, et al (1972), was observed also on the brown portions of damaged needles in late summer and fall. One to several dark bands were often found on the dead portions of needles. Salt damage may be scattered or continuous throughout a tree. Many trees of all sizes showed symptoms throughout the crown; in other cases the tops or the lower portions of the crowns were affected. The reasons for differences in the extent of damage and in the locations of symptom development are not fully understood; these differences are probably associated with the pattern and extent of salt uptake by the root system, as well as by absorption of salts through foliar contact.

The advanced symptoms of salt damage may be a complete browning of the foliage, and subsequent death of the tree. Field diagnosis of salt damage at this stage is questionable and the symptom may be confused with other causes of tree death. Laboratory diagnosis is needed to confirm salt damage at this stage.

White fir. Tip dieback of the needles of white fir is the primary symptom of salt damage. Because the needles are short and oriented on the branches in a nearly flat plane, and because they normally persist and function on branches for many years, the circular "halo" effect of damaged foliage was not observed on firs as it was on pines. From a distance, salt-damaged firs showed various degrees of foliar browning.

Firs, more than any of the other species observed, exhibited an irregular pattern of damage within the crown. Some trees were damaged throughout the crown, some had top damage, others showed lower crown damage, and others showed only scattered crown damage. One variation in the type of damage to firs was vividly illustrated by several trees which had a definite spiral pattern of damage. The most plausible explanation for this pattern is that damaging levels of salt were taken up through one portion of the root system only and translocated upward through the trunk in a spiral manner, causing foliar damage only to the branches using the water and salts in this translocation stream. A spiral translocation pattern of water uptake in red fir has been reported by Owston, et al (1972). Thus, uptake of salts by portions of a root system and differing translocation patterns within trees may account for scattered and variable patterns of salt damage within the crowns of firs, and possibly of other conifer species.

True firs with advances symptoms of salt damage have little foliage and thin crowns. Dead trees, or trees with all brown foliage, should be analysed in the laboratory to determine if salt contributed to the death of the tree.

Incense-cedar. Symptoms of salt damage to incense-cedars appeared different from those observed on pines and firs because of the growth characteristics of the foliage. Incense-cedars, unlike pines and firs, have a fan-like pattern of foliage and branch growth, and small, scale-like leaves that are not readily distinguishable from the stem segments. Because of these growth differences, tip dieback of the foliage of incense-cedars is not easily recognized from a distance; rather, damaged trees have sparse foliage and exhibit a brownish cast as a result of extensive foliage dieback. However, close observation often reveals distinct tip dieback.

RESULTS

DETECTION AND INCIDENCE SURVEY

The general location and the extent of tree damage are shown in Figure I.

In all, 299 sites were found to contain one or more trees showing symptoms of salt damage. Trees of all sizes were affected. Damage was noted on saplings as well as on large sawtimber-size trees, and damage appeared to be as severe on large trees as on small ones.

Along the highways within the San Bernardino National Forest all of the major species of conifers were damaged to some extent. Ponderosa pine, Jeffrey pine, Incense-cedar and white fir were the species most commonly damaged, as they are the most abundant. Sugar pines were severely damaged in certain locations and appeared to be particularly susceptible. Big cone Douglas-fir (Pseudotsugae macrocarpa; (Vasey) Mayr) and Coulter

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FIGURE 1. The locations of salt-damaged roadside conifers on the San Bernardino National Forest, June 1975.

pine (Pinus coulteri D.Don)--found scattered along highway 38--were also affected by salt.

San Gorgonio R.D. Highway 38--extending east from Camp Angelus to the south fork of the Santa Ana River--was the most severely affected area on the Forest. The majority of the affected conifers were located on the north shoulder of the road; however conifers on both sides of the road were injured.

In the spring of 1975, Erl Everest--forester on the Ranger District--surveyed a 14.5 mile portion of the affected area. Using the damage rating system developed by Scharpf and Srago, he determined that 1,476 trees on that section of highway displayed symptoms of salt damage; 1,115 trees were lightly affected, 71 trees were moderately affected, and 290 trees were severely affected. All species of conifers were damaged to some extent.

Big Bear R.D. There was little observable damage along the major roads on the Big Bear R.D. The only areas of extensive damage were on highway 18 from mile post 45.57 to the Big Bear Lake dam and along the Arctic Circle (Hy 18). In the dam area, Jeffrey pine, Sugar pine, white fir, and incense-cedar displayed salt damage symptoms, and along the downslope of the Arctic Circle scattered sugar pine displayed similar symptoms.

A few scattered Jeffrey pines displayed salt damage symptoms along Big Bear Blvd (Hy. 38) in Big Bear City. These trees were very close to a needle miner infestation and therefore the majority of this area was left out of the survey.

Arrowhead R.D. The roadside survey began at the Red Rock Wall on highway 18. To the east, there was scattered salt damage on both sides of the road where the road was level and on the downhill side of the road in other areas. From the intersection of forest road 2N13 and highway 18 to just west of Snow Valley the damage was much more intensive.

The survey was interrupted just west of Snow Valley because of a needle miner infestation. It was felt that the salt damage symptoms may be confused with the needle miner damage. Approximately one half mile east of Snow Valley the survey was continued. From this point to the Lakeview Maintenance Yard there was scattered damage to ponderosa and sugar pine along the edge of the highway.

At the Lakeview Maintenance Yard there were dying trees exhibiting symptoms of salt damage around where the salt was stored. There is also an unnamed creek running by the edge of the salt storage area; along the bank of the creek downhill from the storage area there was also evidence of salt damage.

Around the east side of Lake Arrowhead on highway 173 there was scattered damage to ponderosa pine, sugar pine, white fir, and incense-cedar. This damage continued down to the dam. On the west side of the Lake along highway 189 there was similar damage on the same species.

San Jacinto R.D. There was very little evidence of salt damage on the San Jacinto Ranger District. There was scattered damage on ponderosa pine on highway 243 north of Idyllwild and east and west on highway 74 from the intersection of highway 243 and 74.

The most heavily damaged area was on highway 74 from Keen Camp summit to Garner Valley.

DETERMINE IF THERE IS A CORRELATION BETWEEN THE CONCENTRATION OF CHLORIDE IONS IN THE CONIFER FOLIAGE AND THE DAMAGE RATING

The concentration of chloride ions in trees showing different intensities of symptom expression were grouped and compared. The groups were severe, moderate, light and no (control) symptom expression.

The average percent of dry weight of chloride in the foliage tissue was 1.214, 1.143, 0.936 and 0.065 respectively.

Analysis of variance and the Tukey W procedure were used to analyse for significance.

Table I

Tukey W Procedure			
Range			
C[1]	L[2]	M[3]	S[4]
0 .326	0.675	1.404	1.475

Tukey W Procedure shows that the concentration of chloride ions in the needles of those trees displaying symptoms was significantly greater than the needles in which there were no observable symptoms.

1/ Control (none) 3/ Moderate

2/ Light 4/ Severe

Table 2

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Table 2

Symptom Expression	Analysis of Variance Confidence Internal
Severe	1.193 ± .157 **
Moderate	1.143 ± .141 **
Light	0.936 ± .167 **
Control (none)	0.063 ± .021

Analysis of Variance also shows that those trees displaying salt damage symptoms had significantly higher concentrations of chloride ions in the needle tissue.

Both methods showed that the percentage of chloride ion in the foliage tissue of those trees with observable symptoms was significantly greater than the percentage in the controls, by at least a factor of nine. There were also differences in the concentration of chloride in the foliage of trees between the three damage rating classes; however, these differences were not statistically significant at the 5% level.

RELATIONSHIP BETWEEN CONIFER DAMAGE AND PROXIMITY TO THE TREATED HIGHWAYS.

The relationship between the concentration of chloride ions found in the conifer foliage and the proximity of the trees to the highway was compared using polynomial regression and analysis of variance.

The results of the analysis were significant at the 5% level ($F = 6.23^*$); however the correlation coefficient could account for only 11 percent of the variability in the sample.

There was an inverse relationship signified by the Beta coefficient $B = -.107963$, indicating that the concentration of chloride ions in the conifer foliage decreased as the distance from the highway increased. However, this trend was very weak and a much larger sample size would be required to determine the true significance of the trend.

DISCUSSION AND CONCLUSIONS

The predominant visible damage to conifers was within 100 feet of the highway. There were approximately 299 sites in which the foliage of conifers (white fir, ponderosa, Jeffrey, coulter, and sugar pines, and incense-cedar) displayed symptoms commonly associated with damage caused by highway deicing salt. Some of the most severe damage occurred at highway sites that receive little direct sunlight, indicating that the highway there may be receiving more salt than in sunlit sites.

When foliage samples collected from those trees showing symptoms were analysed to determine the percentage of chloride in the foliage tissue, the levels in the damaged tissue were at least nine times greater than in the foliage of trees not exposed to highway deicing salt.

Data was also collected and statistically analysed to determine if there was a relationship between the concentration of chloride in the foliage tissue and the distance from the edge of the highway. The analysis showed that there was an inverse relationship and that the relationship was significant. However, the correlation coefficient could account for only 11 percent of the variability within the sample. Therefore the true significance of the relationship is not known.

From this evidence and the correlation between application of highway deicing salt and roadside damage shown in Fig. 1, it must be concluded that highway deicing salt is a cause of damage to roadside conifers in the San Bernardino National Forest.

RECOMMENDATION

It is recommended that studies be conducted on the use of highway deicing salt in the San Bernardino National Forest. These studies should examine the effects of highway deicing salts on soil properties, the accumulation of salts in the soil, the contribution of these salts to soil erosion, and their effects on water quality and vegetation associated with deiced highways in the San Bernardino National Forest.

Studies should be initiated also on methods to reduce salt damage by testing different salt and abrasive mixtures, diverting or directing road surface runoff, and planting salt-tolerant vegetation to enhance highway rights-of-way when and if these salts must be used.

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